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**Published Utility Model Heisei 5-45102**

**name of the utility model:** linear motor cooling mechanism  
**applicant:** Yaskawa  
**application date:** 2-24, 1988  
**published date:** 8-31, 1989

**[range of claims]**

1. In a linear motor cooling mechanism where a linear motor stator is a coiled bobbin made of insulation material having a coolant path inside and coolant is supplied to the coolant path through pipe arrangement from outside,  
a linear motor cooling mechanism comprising:  
a coil (bobbin) divided in two parts, made of a thermal conductor material and having a coolant path inside;  
mold resin with high thermal conductivity which covers the coil around the bobbin;  
heat insulating resin which covers the mold resin;  
a closed circuit pipe arrangement connected to the both ends of the coil bobbin; and  
a radiator and a pump placed in the middle of the pipe arrangement.
2. A linear motor cooling mechanism described in claim 1 where the shape of the coolant path is a quasi-rectangle.
3. A linear motor cooling mechanism described in claim 2 where inside of the coolant path is rugged.

**[details of the utility model]****[industrial application]**

This utility model relates to a linear motor cooling mechanism, especially a cooling mechanism to cool an armature coil where coils are wound on front and back surfaces of fixed coil bobbin alternately.

**[prior art]**

Conventionally, natural cooling has been applied in general for cooling of linear motor armature coil, while compulsive cooling has been rare.

As a reference, Fig. 7 illustrates a cross section of a wire cable where coolant flows inside.

Along the inner periphery of outer insulation 75, element wire units 71 containing wires 72 are arranged; parallel to the necessary number of element wire units 71 toward the center of the cable, cooling ducts 74 are arranged; inner gap is filled with thermal conductor filling 73; Jule's heat that wires 72 generate is cooled by coolant.

[problems the idea tries to solve]

In a conventional linear motor, nonuniform temperature distribution occurs in the linear motor mechanism part. Therefore, the conventional type linear motor could not be employed at the driving part of machines such as accuracy positioning table where even a subtle temperature induced deformation was not allowed.

One driving method to restrict heat generation to a minimum is setting constant of linear motor at the rating or higher and driving at a lower rating to keep the temperature rise small. Then, the size of the linear motor turns out to be too large.

There is also a method to apply coil to movable parts in order to make a heat generating part small, where the processing of current supply line becomes a problem; particularly, in synchronous machines where magnets are arranged in the fixed part, the linear motor becomes too costly.

Though not the case with linear motor, in the method shown in Fig. 7 of the published patent Showa 59-4932 where coils (wires??) are placed around several or several tens of (coolant) tubes, flow quantity of the coolant can not be increased due to high flow resistance. The cooling path can not be bent in an extreme way, nor the path can be branched off, where the connection of flow paths could be too troublesome and the shape of coolant path can not be modified easily.

This idea was devised in order to cope with above issues; the purpose of this idea is to offer a linear motor cooling mechanism where, by using a coil bobbin to fix linear motor coil as a coolant path, the motor effectiveness is improved because contact area with coolant becomes large, heat generated at coil is effectively absorbed and thermal deformation due to temperature rise and temperature distribution is kept to a minimum, and heat transfer to the outside of stator coil is prevented so that the adjacent machines would not be influenced by the heat.

[means to solve the problem]

In order to achieve above purposes,

in a linear motor cooling mechanism where linear motor stator which is coiled bobbin made of insulation material having a coolant path inside and coolant is sent to the coolant path through pipe arrangement from outside,

the linear motor cooling mechanism by this idea is characterized by comprising:

a coil bobbin divided in two parts, made of a thermal conductor material and having a coolant path inside;

mold resin with high thermal conductivity which covers the coil around the bobbin;

heat insulating resin which covers the mold resin;

a closed circuit pipe arrangement connected to the both ends of the coil bobbin; and

a radiator and a pump placed in the middle of the pipe arrangement.

[operation]

Coolant 11 can directly cool the coil bobbin 14 inside the linear motor 9 constituted in above mentioned manner. On account of heat insulation resin 13, heat leakage from the linear motor 9 is extremely small, so most of the heat generated in coils 1, 2 and 3 is removed from the motor by coolant 11.

Since the shape of the (coolant) path 12 of the coil bobbin 14 can be formed freely, contact surface area can be increased without increasing flow resistance. Therefore, it is possible to obtain the most effective cooling shape. [For example, inside surface can be rugged as shown in a, b and c of Fig. 5.] Coolant path can be freely diverged inside the linear motor 9 so that the surface of longer direction of the motor has uniform temperature distribution.

Above operation makes it possible to keep the temperature of the linear motor 9 constant; further, a linear motor with small temperature gradient and without heat generation nor deformation can be offered.

[embodiment]

Following is the explanation of an embodiment of this idea referring to the figures:

In Fig. 1 and 2, inner and outer walls of the coolant path 12 is formed by coil bobbin 14 which is

made of resin mold with high thermal conductivity or metal such as aluminum and divided in two parts by cut surface 15; armature coils 1, 2 and 3 are coiled around the outer surface of coolant path 12 in a spiral.

While the coolant 11 passes through the coolant path 12 formed inside the coil bobbin 14, for example, from left to right, it absorbs and takes away heat generated at armature coils 1, 2 and 3, exchanging heat with wall surface.

The coil bobbin 14 and armature coils 1, 2 and 3 are entirely molded by resin 10 with high thermal conductivity, which is further molded by heat insulation resin 13 so as to prevent heat from leaking outside by thermal conduction. Therefore, heat generated at the motor armature coils 1, 2 and 3 does not run away, but most of it is carried out by coolant 11.

Thus, temperature rise of outer surface of the linear motor armature can be kept to a minimum.

Following is the method according to another embodiment of this idea.

Fig. 5 illustrates some improvements of coolant path 12: Fig. 5 (a) shows an embodiment having a coolant path of teeth-like shape, Fig. 5 (b) shows an embodiment having a coolant path of wavy shape and Fig. 5 (c) shows an embodiment having coolant path shaped like a gourd. In these cases, molding or extrusion will be easy by making coil bobbin 14 in two parts (left and right sides) and adhering them by heat pressure etc.

Fig. 6 is another embodiment of this idea: heat absorption part 5 is formed wherein flow path of coolant 11 is divided into several parts in the longer direction (moving direction). Coolant 11 is sent to the coolant path 12 of each division from the coolant supply inlet 16, 16 and 16, and discharged from 17, 17 and 17, making the temperature distribution of armature coils 1, 2 and 3 along the longer direction uniform.

In this embodiment shown in Fig. 6, armature coils 1, 2 and 3 are coiled around the coil bobbin 14 and the coolant supply inlets 16 and outlets 17 are arranged in a manner that no pitch mislocation will occur within the effective length of movable element due to the pipe arrangement, preventing cogging when thrust is generated in the linear motor.

[effect of this idea]

Thus constituted, a simple structure of this idea can directly and effectively cool linear motor coil without changing the characteristics of the linear motor; there is almost no heat leakage outside, temperature is maintained at a constant in regular temperature, and a uniform temperature distribution of a linear motor in the longer direction can be maintained.

#### brief explanation of figures

Fig. 1 is a perspective view of the important part of one embodiment of this idea.

Fig. 2 is a cross section (of the important part of one embodiment of this idea).

Fig. 3 is a side view and a front view to illustrate how to coil the armature coil.

Fig. 4 is a circular system diagram of coolant.

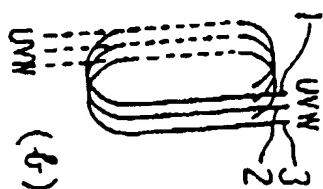
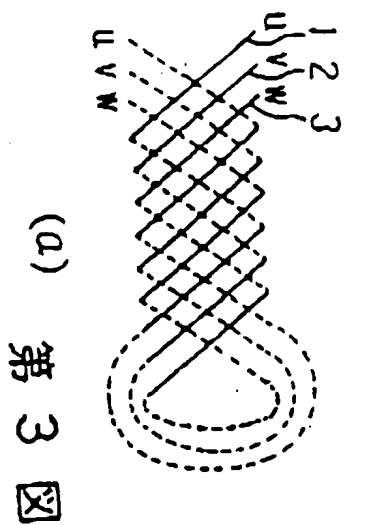
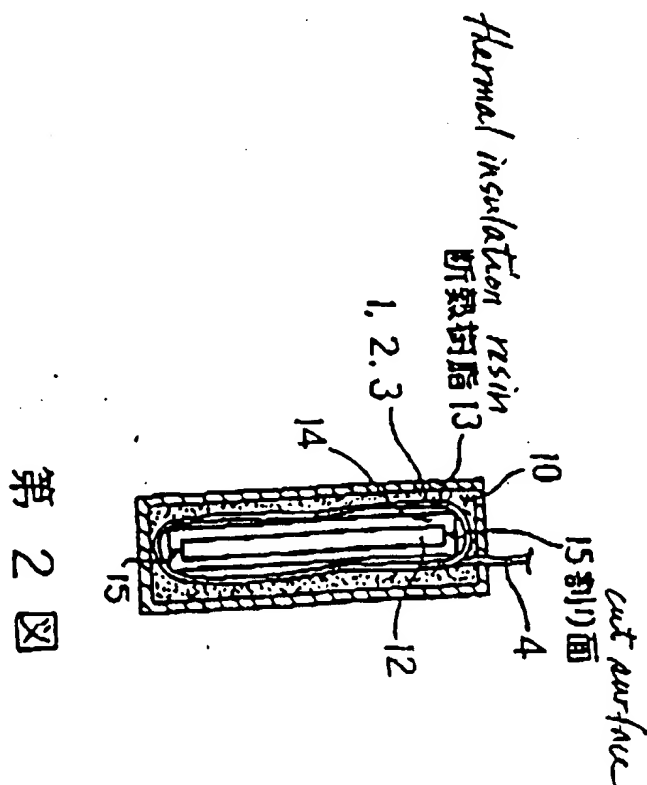
Fig. 5 is a cross section of another embodiment of this idea.

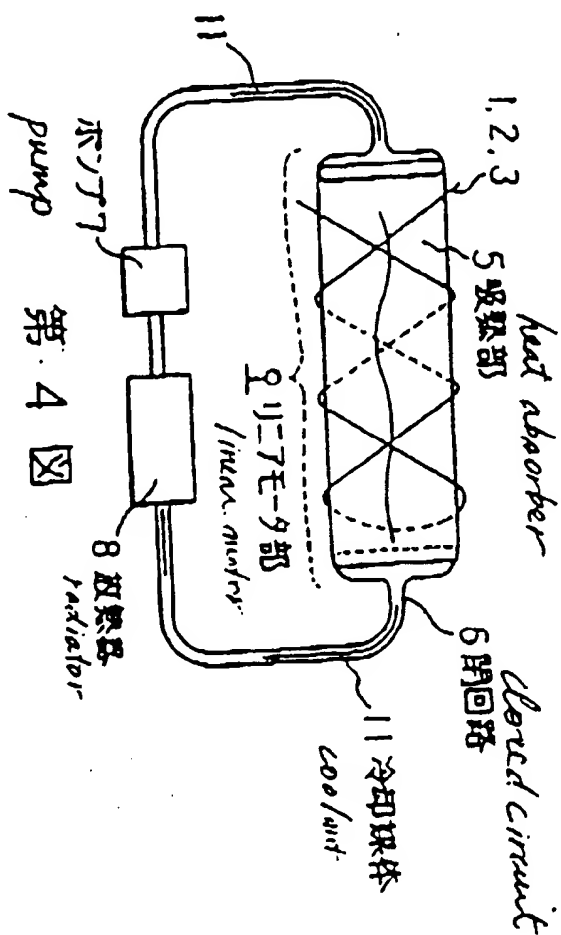
Fig. 6 is a schematic to illustrate another embodiment of this idea.

Fig. 7 is a cross section to explain the prior art.

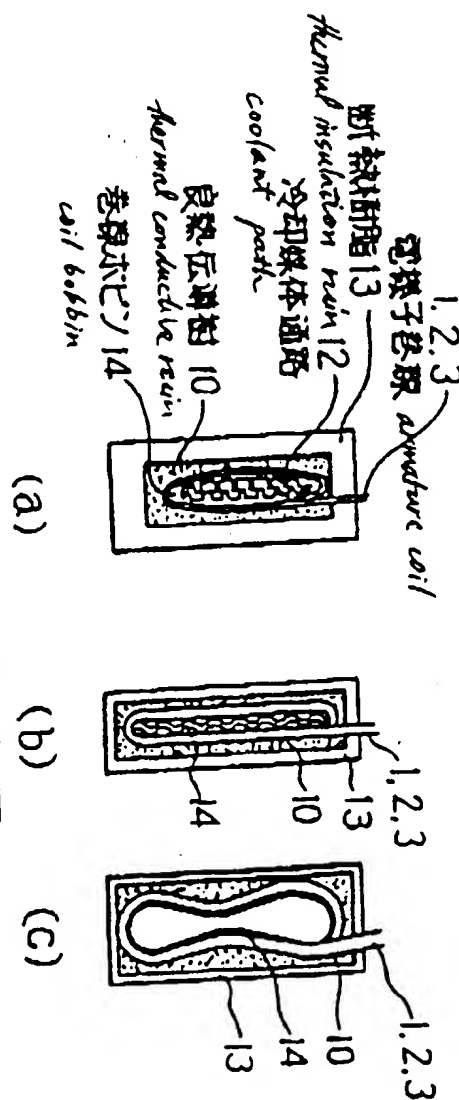
1. U phase armature coil
2. V phase armature coil
3. W phase armature coil
5. heat absorber
6. closed circuit
7. pump
8. radiator
9. linear motor
10. thermal conductive resin
11. coolant
12. coolant path
13. thermal insulating resin
14. coil bobbin
15. cut surface
16. coolant inlet
17. coolant outlet



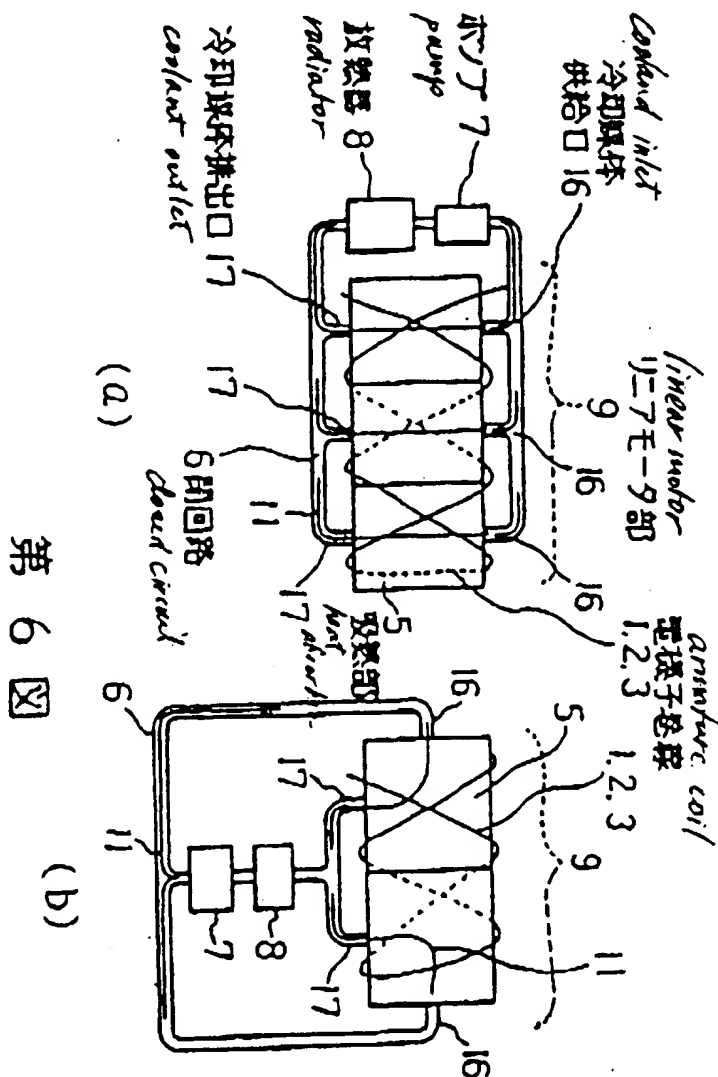








第 5 図



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